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Terrestrial isopods (Crustacea: Oniscidea) from the remote Greek island Antikithira and its surrounding islets

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Terrestrial isopods (Crustacea: Oniscidea) from the remote Greek island Antikithira and its surrounding islets. - Terrestrial isopods from the southwestern Aegean island group of Antikithira are recorded here for the first time. Collecting was done on three islands, Antikithira, Prassonisi and Lagouvardhos, and a total of 20 species was found. One of them is new for science and is described here. Finally, a biogeographic interpretation of the results is attempted.

Key-words: Crustacea - Isopoda - taxonomy - biogeography - Aegean Islands.

INTRODUCTION

The insular invertebrate fauna of Greece and especially that of the small remote islands, is insufficiently known. A serious effort in the direction of intensive collecting on many isolated islets of greek seas has been undertaken by a group of researchers from the University of Athens (author included), under the supervision of Dr. M. Mylonas and financially supported by the "A. Leventis Foundation". The present study has resulted from this research program. Its aim is to present the first references of Oniscidea from the group of islands that ly between the northwestern corner of Crete and the southern parts of Kithira and is composed by Antikithira, Prassonisi, Lagouvardhos and several smaller bare-rock islets (Fig. 1). As the research project is currently going on, records from other islands will be considered in future publications.

There is a lot of biogeographic interest for this island group because it lies at a key location of the southern Aegean Arc. It forms a "stepstone" bridge between conti-

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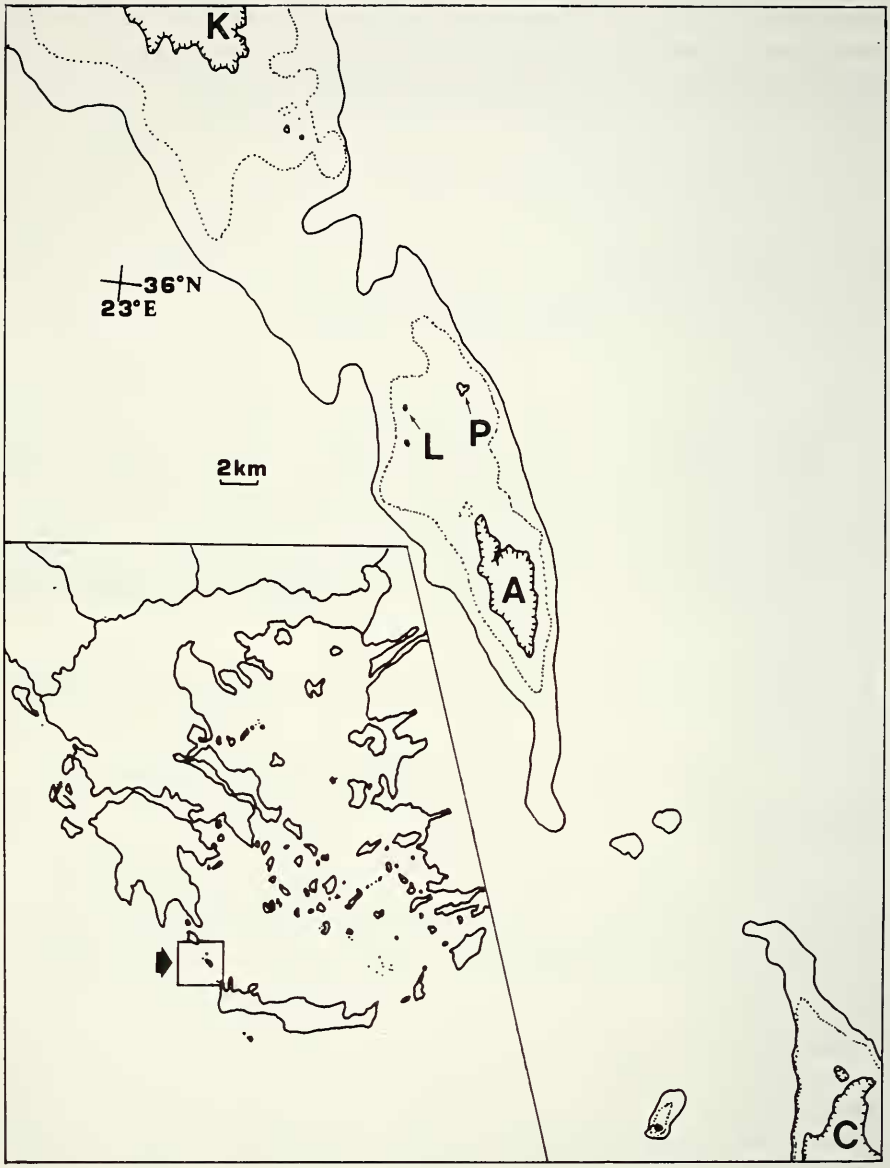


FIG. 1

Map of study area. Isobaths of 200 m and 100 m are represented by solid and dotted lines, respectively. A: Antikithira; K: Kithira; P: Prassonisi; L: Lagouvardhos: C: Crete.

nental Greece (to where Kithira biogeographically belongs) and Crete. The faunal composition of the Antikithira group can provide a lot of information on the paleogeography and zoogeography of this region.

Terrestrial isopods are fairly well known from Crete (SCHMALFUSS, 1972a; 1979) and southern Greece (Peloponnese) (STROUHAL, 1938; SCHMALFUSS, 1979). For Kithira island only a few sparse references exist (see revision in SCHMALFUSS, 1979; 1982) and no reference at all from Antikithira.

The material collected has been deposited at the following institutions: Zoological Museum of the University of Athens (ZMUA), Muséum d'Histoire naturelle de Genève (MHNG), Staatliches Museum für Naturkunde, Stuttgart (SMNS) and Museo Zoologico dell'Universitá, Firenze (MZUF).

SITES AND METHODS

Collecting has been carried out during 17, 18, 19 and 22.1.1992 (Antikithira), 21.1.1992 (Lagouvardhos) and 20, 21.1.1992 (Prassonisi). On Lagouvardhos islet only Dr. M. Mylonas was able to climb and collect, while on the other islands collecting was carried out by the author, occasionally helped by other colleagues.

Collecting was done by hand, but also leaf litter samples from the most abundant plants were taken and placed in Berlese-Tullgren funnels for arthropod extraction.

A brief description of the study area is given below:

a) A n t i k i t h i r a . (Data from VERIKIOU, 1986). The largest island of the group, with an area of 20 km^2 and a maximum altitude of 378 m a.s.l. Its shape is rhomboid with the large axis 10 km and the small one 3.3 km long. It consists mainly of limestones (Triassic and Cretaceous), but there are also some Neogene deposits. Vegetation is dominated by maquis and phryganic formations, while part of the island (especially Neogene deposits) is cultivated with Gramineae. Antikithira is one of the drier locations of Greece, receiving annually less than 200 mm of rainfall.

b) P r a s s o n i s i . No data have been published for this small islet. Its area (estimated from a 1:10000 map (VERIKIOU, 1986) is about 0.27 km^2 and its distance from Antikithira is 7.5 km. Its heighest point lies lower than 100 m a.s.l. The geological underground consists totally of limestones. The vegetation cover is mainly of herbaceous plants (phrygana and halophytes) but there is a thick copse of maquis shrubs at the western side.

c) L a g o u v a r d h o s . No published data. Area estimated around 0.06 km^2 and maximum altitude of around 25 m a.s.l. Its shape is almost quadrangular and its morphology characterized by steep, vertical sides and a plateau at the top. The only plants growing there are some halophilic herbs and a few Gramineae. The geological underground is limestone. The distance from Antikithira is 7.2 km and from Prassonisi 3 km.

Bathymetry of the area (Fig. 1) can help towards an understanding of its paleogeographic history. Antikithira is connected with Kithira by the 200 m isobath, while inbetween Antikithira and Crete there are depths greater than 400 m. On the

contrary, all the islands composing the investigated group are connected by the isobath of 100 m, a strong indication that during Pleistocene glaciations they formed a coherent piece of land. The geotectonic history of the area, though, is complex and its paleogeography not easily inferred. According to ANASTASAKIS (1988) the greatest portion of the Kithiran - Antikithiran margin and the Antikithiran - W. Cretan strait was submerged during the Middle-Upper Quaternary but the process had already started during Lower-Middle Pliocene. It is difficult to estimate the age of these islands' isolation because tectonic movements in the region have been abrupt and of dramatic scale (DERMITZAKIS, 1972; FLEMMING and PIRAZZOLI, 1981). An uplift of 2.7 m during the last 2000 yrs has been recorded for Antikithira by these authors, while for surrounding areas the scores are even higher. Therefore, one cannot safely assume the actual pattern and sequence of past land connections. Thus, biological information can prove of great value in unfolding the history of this area.

RESULTS

A total of 20 species were found on the three islands, 18 on Antikithira, 10 on Prassonisi and 6 on Lagouvardhos. One species is new to science, while for all species this is the first record from this island group.

The species list and the description of the new species follows below.

Abbreviations: m: males; f: females; j: juveniles.

LIGIIDAE

1. **Ligia italica** Fabricius, 1798

Numerous individuals were observed on all islands.

This halophilous species is present on all islands in large densities throughout the rocky shores. It is a species distributed all over the Mediterranean shores but also present on many Atlantic sites too.

TYLIDAE

2. **Tylos latreillei** Audouin, 1825

1 m, 1 f, Antikithira, 19.1.1992 (ZMUA)

This sand-dwelling halophilous species was collected at a beach lying at the northeastern shoreline of the island. On neither of the other islets is there any such habitat.

HALOPHILOSCIIDAE

3. **Halophiloscia hirsuta** Verhoeff, 1928

3 m, 2 f, 2 j, Antikithira, 19.1.1992 (ZMUA); 4 f, Prassonisi, 20.1.1992 (ZMUA)

This halophilous species has been found at rocky shores among stones and halophilous plants. It is distributed all over the northern Mediterranean coasts.

TRICHONISCIDAE

4. **Monocyphoniscus caniensis** (Vandel, 1958)

35 m, 34 f, Antikithira, 18.1.1992 (ZMUA); 2 m, 4 f same collecting data (MHNG)

This species inhabits the litter-layer of maquis vegetation (*Pistacia lentiscus*) at the central part of the island. It is a blind, small, humicolous species previously recorded only from certain caves of Crete. Even though, until now, it has been considered as a troglobitic species, I have collected it from several locations outside caves, especially in places with very humid soil conditions. These locations lie on some of the Cyclades islands (personal data) and therefore the actual distribution of the species is wider than recorded in the literature.

5. **Thrichoniscus** sp.

2 m, 11 f (some with eggs), Antikithira, 17-18, 22.1.1992 (ZMUA); 1 m, 1 f, Prassonisi, 21.1.1992 (ZMUA)

The specimens were collected from the litter-layer of several plants (mainly maquis) wherever there was enough humidity. The present state of our knowledge on the greek species of *Trichoniscus* is far from being satisfactory. A sound revision of the genus in Greece is necessary before any safe determination is possible. For the moment it suffices to say that the same species is present on both Antikithira and Prassonisi and that it seems to be related to *T. halophilus* Vandel, 1951.

BATHYTROPIDAE

6. **Rodoniscus anophthalmus** Arcangeli, 1934

2 m, 2 f, Prassonisi, 20.1.1992 (ZMUA)

This endogean species has been recorded so far only from the Dhodhekanese (southeastern Aegean sea). In my personal collection (unpublished data) there are specimens also from Crete and the Cyclades.

PLATYARTHRIDAE

7. **Platyarthrus schoebli** Budde-Lund, 1885

1 m, 9 f, Antikithira, 17-19.1.1992 (ZMUA); 2 f, Prassonisi, 20.1.1992 (ZMUA); 1 m, 3 f, Lagouvardhos, 21.1.1992, leg. Mylonas (ZMUA)

This species lives in ant-nests and is distributed all around the Mediterranean countries.

PHILOSCIIDAE

8. **Chaetophiloscia cellaria** (Dollfus, 1884)

3 m, 19 f (10 with eggs), Antikithira, 17-19, 22.1.1992 (ZMUA); 1 m, 16 f (12 with eggs), Prassonisi, 20.21.1.1992 (ZMUA); 1 f, Lagouvardhos, 21.1.1992, leg. Mylonas (ZMUA)

This species was found in the humid litter-layer of several plants and at several other humid microsites. It is distributed all over the northern Mediterranean countries.

PORCELLIONIDAE

9. **Leptotrichus naupliensis** (Verhoeff, 1901)

4 m, 4 f, Antikithira, 17-19.1.1992 (ZMUA)

This species is present on cultivated land and on sandy soil. It is distributed throughout the eastern Mediterranean.

10. **Porcellinionides pruinosus** (Brandt, 1833)

4 m, 5 f, Antikithira, 17-19.1.1992 (ZMUA); 11 m, 16 f, Prassonisi, 20, 21.1.1992 (ZMUA); 18 m, 13 f, 6 j, Lagouvardhos, 21.1.1992, leg. Mylonas (ZMUA)

This species is present in most kinds of terrestrial habitat. It is anthropophilous and cosmopolitan.

11. **Porcellionides myrmecophilus** (Stein, 1859)

5 m, 3 f, 1 juv., Antikithira, 17-19.1.1992 (ZMUA)

A species very similar to *P. pruinosus* but which is usually found near ant-nests. On Antikithira it was collected at humous-rich sites of cultivated land and in ant-nests. It is distributed all around the Mediterranean countries.

12. **Porcellio laevis** Latreille, 1804

4 m, 4 f, 5 j, Antikithira, 18.1.1992 (ZMUA)

This species was found at very humid sites near water. It is anthropophilous and has a cosmopolitan distribution.

13. **Porcellio obsoletus** Budde-Lund, 1885

3 m, 4 f, Antikithira, 17.18.1.1992 (ZMUA); 2 m, 3 f, Prassonisi, 20.1.1992 (ZMUA)

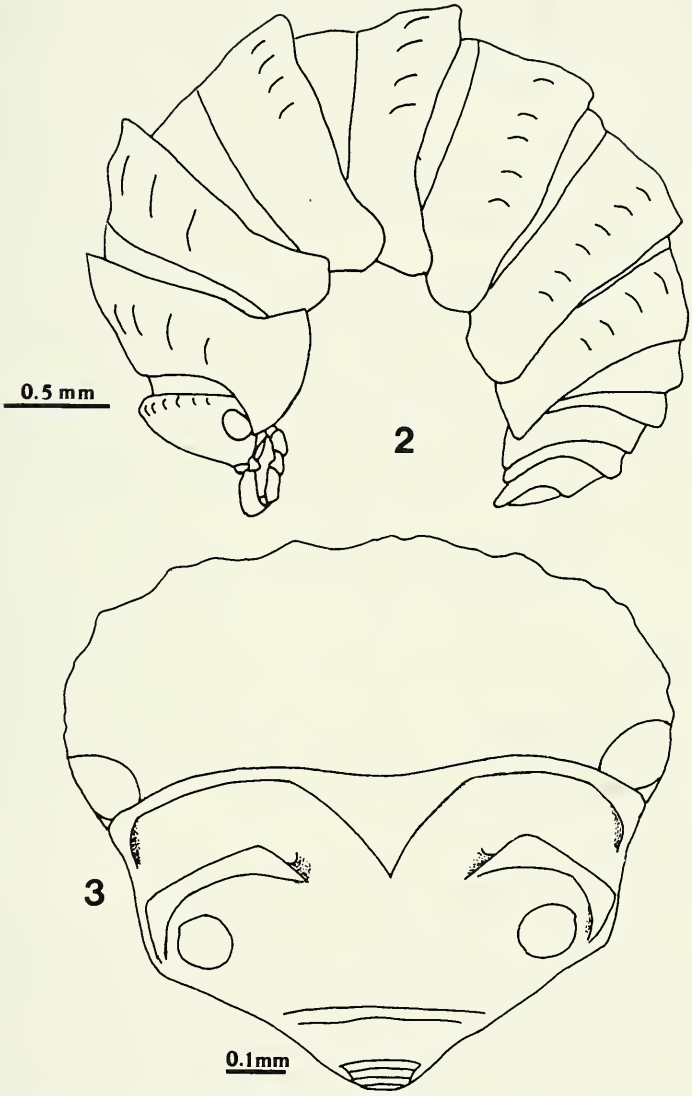
This species inhabits maquis vegetation but can also be found in various habitats with enough calcium and humidity. It is an eastern Mediterranean species.

ARMADILLIDIIDAE

14. **Troglarmadillidium ariadni** (Vandel, 1958)

3 f, Prassonisi, 20.1.1992 (ZMUA); 1 f. Lagouvardhos, 21.1.1992, leg. Mylonas (ZMUA)

No safe identification can be made because only females were collected. The similarity of these specimens to those *T. ariadni* is very striking and since no other species with such character states has been described from the region, it is almost certain that they belong to this species. All specimens were found under stones deep in the soil. *T. ariadni* has been recorded from Cretan caves and has been regarded as a troglobitic species. If the present identification proves to be correct, then we are again in front of the same phenomenon as with *M. caniensis* described above: certain species considered troglobitic are also living in very humid sites away from caves or are humicolous. This phenomenon may prove important in understanding the process of acquiring troglobitic adaptations.



FIGS 2-3

Troglarmadillidium halophilum n. sp. Holotype (male, 4.3 mm). 2: Lateral view of whole animal; 3: Cephalon in frontal view.

15. **Troglarmadillidium halophilum** n. sp.

Holotype: 1 m, 4.3 mm, Antikithira, 19.1.1992, leg. Sfenthourakis (ZMUA)

Paratypes: 7 m, 3 f, same collecting data (ZMUA), 2 m, 2 f, same collecting data (MHNG), 1 m, 1 f, same collecting data (MZUF-4035), 1 f, same collecting data (SMNS); 2 f, Lagouvardhos, 21.1.1992, leg. Mylonas (ZMUA)

C o l o u r . Yellowish-white with brown patches wich are denser on tergites than on epimera.

O r n a m e n t a t i o n . Cephalon and tergites covered by small and diffuse tubercules that fade towards epimera and pleon.

A n t e n n u l a . Consisting of three joints. There is a bunch of aesthetascs on the apex of third joint.

A n t e n n a . First flagellar joint 2.5 times shorter than second (Fig. 7).

E y e s . Functional, consisted of 10 ommatidia.

C e p h a l o n . (Fig. 3) The posterior margin of the frontal triangle is complete and formed by the frontal line (*Eluma*-type). Antennal lobes are oblique.

P e r e i o n . There is no schisma at the first epimeron. The posterior margin of pereion-epimeron i is moderately arched (Fig. 2). Seventh pereiopod of males sexually differentiated but to a minimal degree: the ischium of males is slightly concave at the ventral side and with a few more hard setae than that of females (Fig. 4).

P l e o n . Male pleopod 1 as in Fig. 5-6.

T e l s o n . Trapezoidal, with rounded angles (Fig. 8).

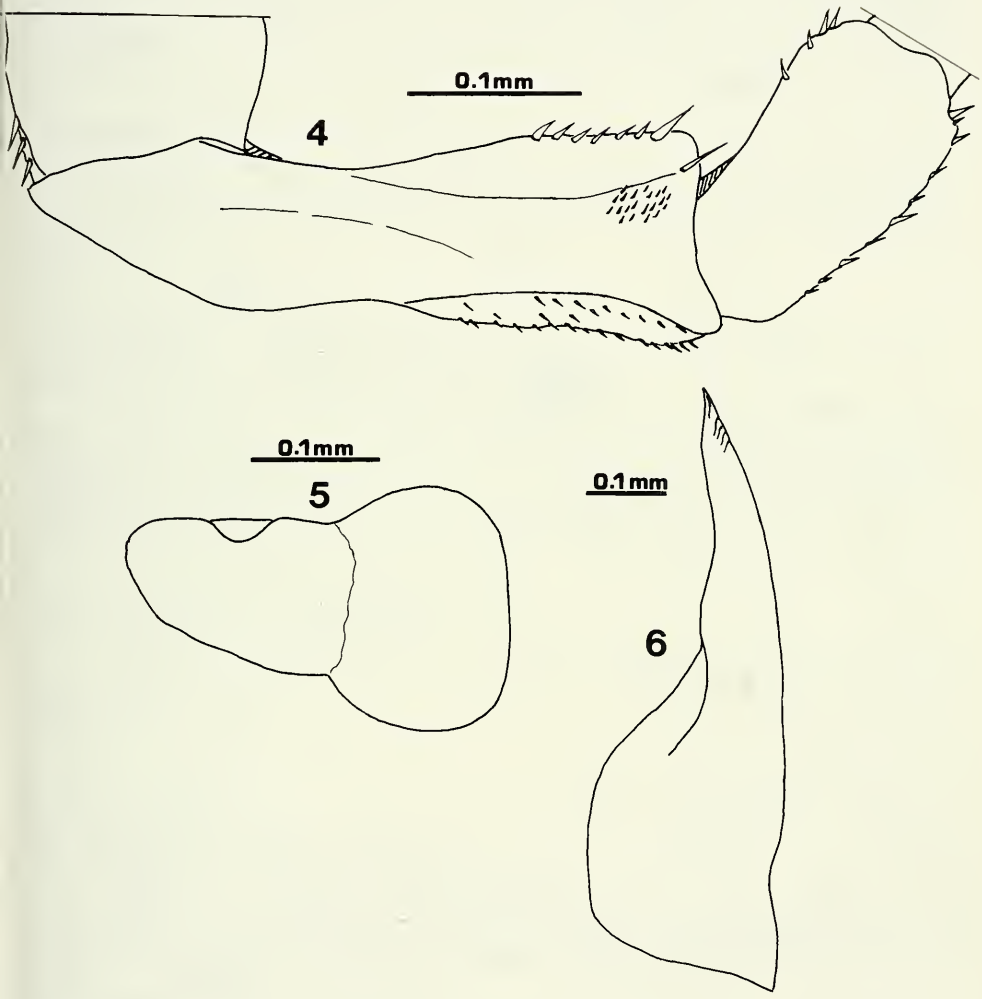
U r o p o d s . As in Fig. 9. Exopodite as wide as long.

R e m a r k s . SCHMALFUSS (1972b) described a species of *Cristarmadillidium* Arcangeli, 1935 from the greek island of Gavdos (*C. gavdense*) which he later ascribed to the genus *Troglarmadillidium* Verhoeff, 1900 (SCHMALFUSS, 1975). In the original descriptions of the two genera there are no safe diagnostic criteria and the taxonomic status of various related taxa (e.g. *Platanosphaera* Strouhal, 1956 and *Illyricosphaera* Verhoeff, 1933, sometimes considered as subgenera of *Troglarmadillidium* and sometimes as separate genera) remains obscure.

T. halophilum is very similar to *T. gavdense* and therefore I preferred to ascribe it in the same genus until a revision of this group is available.

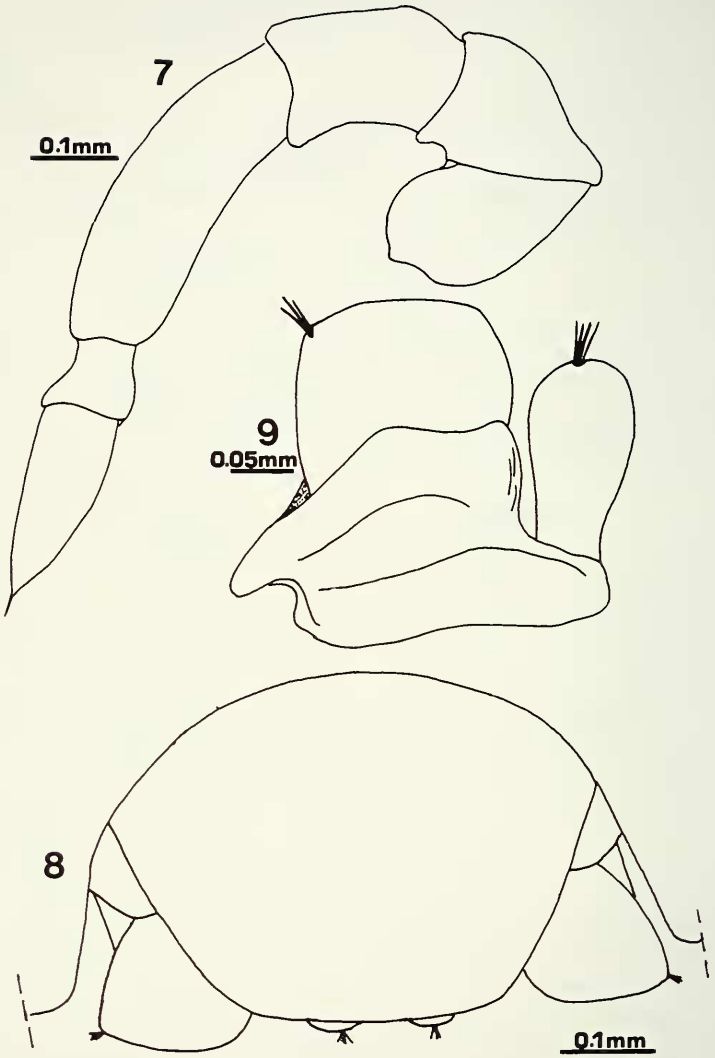
The two species differ in the number of ommatidia (10 in *T. halophilum*, 5 in *T. gavdense*), in the presence of small tubercules (only in the former), in the shape of male pleopod 1, in the stronger coloration of *T. halophilum* and in the male pereiopod 7 (not sexually dimorphic in *T. gavdense*). From the other greek species of the genus (*T. ariadni* and *T. beieri* Strouhal, 1956) it is easily distinguished by the presence of functional eyes, the trapezoidal telson, the coloration and the concave posterior margin of the first pereionepimere.

Epigean habits of this species and related character states (eyes, coloration) indicate a primitive status in the genus, as most *Troglarmadillidium* species are blind and unpigmented. The evolutionary trends for ommatidia reduction and loss of coloration are present in various degrees in greek species. A possible transformation series is the following: *T. halophilum* - *T. gavdense* - *T. beieri* - *T. ariadni*. The first three are epigean and the last troglobitic-endogean.



FIGS 4-6

Troglarmadillidium halophilum n. sp. Holotype (male, 4.3 mm). 4: Ischium and merus of pereiopod 7; 5: Pleopod-exopodite 1; 6: Pleopod-endopodite 1.



FIGS 7-9

Troglarmadillidium halophilum n. sp. Holotype (male, 4.3 mm). 7: Antenna; 8: Telson; 9: Uropod.

Ecology. The specimens from Antikithira were collected under stones and in the sandy soil of a rocky formation a few meters away from the shoreline, at the northeastern part of the island. The specimens from Lagouvardhos were found under stones lying among several halophilic plants at the only plant-covered plateau of this tiny islet, around 25 m above sea level. Both sites are affected by sea-spray throughout the year and even by waves during stormy days. Therefore, the species should be considered as a real halophilic or, at least, as an euryoecious, very tolerant of saline environment.

16. **Armadillidium bicurvatum** Verhoeff, 1901

18 m, 18 f, Antikithira, 17-19.1.1992 (ZMUA); 1 m, 4 f, same collecting data (MHNG)

This species was abundant in cultivated land but also present in certain maquis sites. It is distributed on both continental Greece (Epirus, Peloponnese, Kithira) and Crete.

17. **Armadillidium cythereium** Strouhal, 1937

20 m, 11 f, 113 j, Antikithira, 17-19, 22.1.1992 (ZMUA); 2 m, 5 f, same collecting data (MHNG); 28 m, 17 f, 2 j, Prassonisi, 20-21.1.1992 (ZMUA)

The commonest species in most habitats (minus littoral and sub-littoral). It has been reported only from Kithira island but SCHMALFUSS (personal communication) considers the south-Peloponnese species *A. laconicum* Strouhal, 1938 as its synonym. Specimens from Prassonisi are smaller and have lighter coloration, probably because of the extreme and harsh ecological conditions met on this small islet.

18. **Armadillidium granulatum** Brandt, 1833

1 f, Antikithira, 18.1.1992 (ZMUA)

This species is present on most calcareous Mediterranean areas that are influenced by the sea.

ARMADILLIDAE

19. **Armadillo officinalis** Dumeril, 1816

12 m, 25 f, 1 j, Antikithira, 17-19.1.1992 (ZMUA)

Abundant at maquis vegetation and near cultivated land. It is characteristic of mediterranean-type ecosystems and is distributed in most mediterranean countries.

20. **Armadillo tuberculatus** Vogl, 1876

8 m, 9 f, Antikithira, 17-19, 22.1.1992 (ZMUA); 2 m, 2 f, same collecting data (MHNG)

This species has been collected at various habitat types but prefers maquis vegetation on calcareous substrate. It is a variable species that is distributed in insular Greece (Cyclades, eastern Aegean islands, Crete and Kithira). The same form of this species is present on Antikithira and Kithira but a distinct one on Crete (SPENTHOURAKIS, 1991).

DISCUSSION

The three islands that constitute the investigated group can be regarded as one biogeographic unit concerning their terrestrial isopods. Some minor differences are due to the exceptional ecological conditions of small islets. Actually, the absence of *R. anophthalmus* and *T. ariadni* from the larger "source" island of Antikithira can be explained in terms of their cryptic behavior: both species are small and cryptic endogean isopods that come near the soil surface (and thus can be found) only when the humidity at their understone microhabitat is very high. Therefore it is easier to collect them on such small islets where understone humidity is almost continuously higher than that of larger islands because of the constant influence of sea spray and of halophilic plants, whose litter layer is maintained humid. Both species can be, therefore, expected from Antikithira too.

TABLE 1

The terrestrial isopods collected on Antikithira island group. AN: Antikithira; PR: Prassonisi; LG: Lagouvardhos; CR: Crete; KY: Kithira; ?: Not recorded here, but widely distributed.

	AN	PR	LG	CR	KY
Ligia italica	+	+	+	+	+
Tylos latreillei	+			+	+
Halophiloscia hirsuta	+	+		+	?
Trichoniscus sp.	+	+		?	?
Monocyphoniscus caniensis	+			?	?
Rodoniscus anophthalmus		+		+	?
Platyarthrus schoebli	+	+	+	+	+
Chaetophiloscia cellaria	+	+	+	+	+
Leptotrichus naupliensis	+			+	+
Porcellionides pruinosus	+	+	+	+	+
Porcellionides myrmecophilus	+			+	+
Porcello laevis	+			+	+
Porcellio obsoletus	+	+		+	+
Troglarmadillidium ariadni (?)		+	+	+	
Troglarmadillidium halophilum	+		+		
Armadillidium bicurvatum	+			+	+
Armadillidium cythereium	+	+			+
Armadillidium granulatum	+			+	+
Armadillo officinalis	+			+	+
Armadillo tuberculatus	+			+	+
TOTAL	18	10	6		

Even though the ecological biogeography of such small and isolated islands is of great scientific interest, it is premature to proceed to such a consideration, because no adequate data on the specific conditions met in this type of Mediterranean ecosystem have been published and not enough islets have been sampled yet. On the other hand, this island group is of particular historical biogeographic interest, as it is located at a key position of the southern Hellenic Arc (for the significance of this region see

ANGELIER and LE PICHON, 1978; LE PICHON and ANGELIER, 1979; PAPANIKOLAOU and DERMITZAKIS, 1981 etc.).

As stated before the predominant question related to biologists, concerns the pattern of successive disjunctions between Antikithira, Crete and Kithira-Peloponnese. Biogeographical approaches can largely contribute in estimating the relative timing of break-ups of connecting landbridges. Did Crete separate at a time very different from that of Kithira? The following discussion is related to this problem.

The species comprising the terrestrial isopod fauna of the Antikithira island group are, in majority, widely distributed in Greece. From a total of twenty, only two species (*A. cythreium* and *T. ariadni*) have a locally restricted distribution and only one (*T. halophilum*) is a local endemic (*Trichoniscus* sp. is very likely to be the same species as the one found on Kithira, southern Peloponnese and probably also Crete).

Therefore, the affinities of the investigated area with Crete and continental Greece are obscured by the poverty of indicative elements. Nevertheless, some comments on certain characteristic distributions can help towards an understanding of past processes:

One endemic species is shared with Kithira (*A. cythereium*) and one with Crete (*T. ariadni*). An additional indication of closer relation with Kithira could be the presence of the same form of *A. tuberculatus* on these two islands alone. But according to SFENTHOURAKIS (1991) this is a weak argument, as the various forms of this species are often distributed in patterns incompatible with known paleogeographic reconstructions.

On the other hand the sommon species of Antikithira and Crete belongs to a genus mostly differentiated in the Cretan area. Also, the local endemic species of Antikithira belongs to this same genus and is related to *T. gavdense* that is an endemic of Crete. Such relationships at the generic level or based on troglobitic-endogean species are, in all possibility, indicative of relatively old connections.

A reasonable combination of the data results in the following hypothesis: A first break-up between Kithira and Antikithira happened early, resulting in a relatively long isolation of Antikithira plus Crete (period of *Troglarmadillidium* differentiation). The splitting of these islands followed at a later time and Antikithira remained isolated for long until a temporary reconnection with Kithira took place, probably during some period of sea-level retraction such as the Würm glaciation. This resulted to the expansion of *A. cythereium* and *A. tuberculatus* on both islands. The separation of the small islets Lagouvardhos and Prassonisi from Antikithira may have happened any time afterwards.

In this reconstruction, the main ambiguity is about the degree of sea-level retraction during glaciations. Scores larger than 100 m have been proposed by several researchers (GREUTER, 1970). In the case of the southwestern Aegean these numbers must be combined with tectonic movements of land that can be of large scale, as already discussed (see "sites and methods". Therefore, an algebric sum of relative sea-level retraction around 200 m is a sound possibility, justifying the proposed scenario.

As a conclusion, it should be stressed that the terrestrial isopod fauna of Antikithira does not support an old continuous isolation of this island group from neighboring regions, since it supports only one local endemic species, while it shares other endemics with both Kithira and Crete.

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